REPAIR OPTIONS

FOR THE

FEDERAL BREAKWATER

EASTPORT, MAINE

MAY 20, 1994

PREPARED FOR:

Eastport Port Authority
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PREPARED BY:

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BCE *Bourne Consulting Engineering*

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1.0 INTRODUCTION

The Eastport Port Authority has an L-shape breakwater consisting of a 50 foot wide by approx. 400 foot long filled bulkhead with a wharf attachment to it's east side of 40 foot by 400 foot. The original fill structure which was constructed in the early 1960's, predominantly acts as a breakwater to protect fishing boats behind it. In about 1983 a wharf structure was constructed on it's easterly side to allow berthing of bulk cargo ships with 40 foot drafts.

The bulkhead has undergone limited repair over the last 10 to 15 years. Recently, a failure of the connection of the wale to the sheeting has occurred and it has become evident that this is a condition that is occurring throughout the structure. Bourne Consulting Engineering was retained by the Eastport Port Authority to make recommendations for immediate repair, as well as develop repair options for long term solution to this problem. This existing facility is critical to the economic vitality of the area as it is a major shipping access for exporting bulk timber cargo. Currently, two to three ships load at the facility each month.

2.0 EXISTING CONDITIONS

The existing breakwater consists of an approach that runs easterly from shore which is 40 feet wide. The bulkhead then extends to the south approximately 400 feet having a 50 foot width through this region. The steel sheet pile bulkhead has two rows of tie rods on the outer bulkhead at El. +4 and +16. It is this outer section of bulkhead running north/south that is exhibiting the problems with the sheeting to wale connection.

Inspection of the site revealed that a portion of the western side about mid-point along the 400 foot length had separated at El. +16 from the wale and an approximate 12 inch gap existed between the wale and the sheeting. This area had been excavated down to the wale and failure of wale to sheeting bolts was observed. The wale, although showing evidence of corrosion, was in good condition and the tie rod, where exposed, was found in good to excellent condition.

A second depression was seen on the western edge down at the southern end and a bowing of the sheeting was observed at that location. However, this condition has existed for some time and to the best of our knowledge, has never been excavated to determine the cause of the settlement.

During the inspection of the bulkhead from the water side, a number of bolts were found missing at El. +16 along the section of failure that extends both north and south of this area. In discussions with the port manager, Brian Nutter, it was determined that several plates have also been lost at El. +4, but not as severe as is now being seen at El. +16.

3.0 IMMEDIATE REPAIR RECOMMENDATIONS

At the present time, the failure of the bolts between the sheeting and wale are resulting in the sheeting moving away from the wale and a redistribution of the loads. Unfortunately, these loads are being redistributed down into the lower wale causing more stress in an area that may be in as poor condition as El. +16. At this time, it is strongly recommended that repairs begin immediately to reinstall the connection between the wale and the sheeting. A recommended repair detail would consist of an all thread bar with plate washers as shown in Figure 1. This would be installed at each pair of sheeting

connections. This work would require that excavation along the edge of the bulkhead take place down El. +16 to perform this work. Care should be made to not remove any of the existing wale to sheeting bolts unless they are already failed. The new connections should be installed as soon as possible.

4.0 LONG TERM REPAIRS

Because of the structure's age and recent repairs, as well as the existing problems encountered, the Eastport Port Authority needs to look at long term solutions for this structure. The structure is critical for the protection of the fishing boats and as a cargo terminal for the foreseeable future, even though the Eastport Port Authority is now progressing to create a new site for their marine terminal.

The obvious recent problems with the bolt connections between the wale and the sheeting at El. +16 reveal that the structure's connections at this point are weakening and alternative or additional connections need to be made at this point. In addition, the existing sheet pile bulkhead has a number of holes which have developed within the zone of approximately El. -6 to El. +4 which have been documented in underwater inspections and which have been patched or plugged with concrete. It would appear that these conditions will continue until the structure can no longer stand. A long term repair would be required to resolve all these issues.

In developing alternatives, it was felt that it was necessary to maintain its breakwater foundation to protect the fishing vessels and small craft behind it. The function of this structure is not only to provide capacity for shipping and vessel access, but also to provide storm protection for the vessels. Any repair would ultimately need to insure that it prevents the wave barrier created by core material of the existing breakwater. Historically, a common solution for replacement of steel bulkheads is to install another outshore of the original. However, on the eastern face a wharf structure now exists which prevents the driving of sheet pile in a standard manner. An alternative to this would be to drive the steel sheeting into the bottom where possible, and in areas under the wharf structure, sheeting would need to be assembled in panels or sections at each end and a method for getting them into position would need to be created by the contractor. One method would be to establish a trolley system which would roll the sections into position where they could then be bolted together after they are into position. In this case, the sheeting would not be driven, but set into the bottom. The length of the sheeting would be determined on what clearance they needed to get into position before they were lowered into position.

All the alternatives presented in this report revolve around the installation of the exterior sheeting being installed. The sheeting size probably would not need to be as large as the existing, although additional analysis would need to be required to make the final determination. The new ring of sheeting would still be based on utilization of the existing sheeting capacity from about -10 to the mudline. The new sheeting would pick up the load above this elevation and extend upward to the top of the breakwater. In the area under the wharf, the sheeting would stop at some point beneath the wharf (probably 5 to 6 ft) but it is felt in an area that has sufficient capacity for the long term. Each of the following alternatives is based on the above sheeting concept and from that develops the method of anchoring the sheet pile walls together by utilizing different construction techniques.

4.1 OPTION 1

This option anchors the sheeting by horizontally drilling the tie rods through the breakwater. The tie rods would be located at approximately the same elevations as the existing tie rods. To minimize the number of tie rods, the system would take full advantage of new materials and their increased strengths. The drilling would be accomplished by using an Odex drilling procedure or other two-tube rotary percussion drilling system. This method of drilling would install a sleeve into the hole which would allow for the tie rod installation. Two different tie back systems were investigated. The two systems chosen were a single threadbar (Option 1A, as seen in Figure 2) and bundled strands (Option 1B, as seen in Figure 3). The increased strength of the bundled strands allowed for less tie backs and therefore less drilling.

Once the tie rods were in place, the space between the sheeting would be filled and the corrosion protection systems for the tie rods would be installed.

4.2 OPTION 2

The second option, as seen in Figure 3, consists of the same type of sheeting installation. The tie rods would be installed by excavating out the backfill material and installing the new rods from the interior of the breakwater. The excavation would extend down to the lower tie rod at El. 4.0. The excavated material would need to be stored off site, which would require trucking. New threadbar tie rods would be installed at the lower level and then the breakwater would be backfilled to the upper level of tie rods. After the upper tie rods are installed, the remainder of the breakwater would be backfilled. Finally, the space between

the new and existing sheet piling would be filled and a new asphalt deck would be installed. Unlike Option 1, which encapsulates the rods in grout, the extent of corrosion protection would consist of just fusion bonded epoxy coating on the threadbars.

4.3 OPTION 3

The third option uses the same type of sheeting configuration along the outshore face, but along the inshore side of the breakwater a "king pile" system would be installed, as seen in Figure 4. The "king pile" system consists of driving steel piles at a certain interval and spanning between the piles with sheet piling. This method allows for larger loads on the wall, which would require only one row of tie rods along this face. The tie rods would be drilled through the breakwater using similar methods already discussed. The tie rods would be drilled horizontally and sloped (similar to Option1) to allow for two rows of tie rods along the outshore wall.

4.4 OPTION 4

This option is a combination of Options 1 and 2. Refer to Figure 5 for a typical section. It would require excavating down to the upper tie rods and installing new threadbars at this level. The breakwater would then be backfilled and a new asphalt deck would be installed. The installation of the lower rods would be performed by horizontal drilling. The drilling operations could be staged around the excavation procedures.

5.0 EVALUATION OF REPAIR OPTIONS

The tidal influence at Eastport Harbor is very substantial and would adversely effect all methods of construction. Drilling or excavation would have to be planned and executed around the tide levels and would increase the time frame of both operations. This tidal condition will also increase the corrosion potential of the steel which would favor the drilling method for installing the tie backs, since increased corrosion protection could be achieved by grouting the tie rods.

Using bundled strands (Option 1B) as the tie back system would increase the susceptibility of the breakwater to corrosion problems to the site and which generally is avoided in coastal structures. This, combined with a relative high construction cost, rates this alternative less attractive.

Where excavation of the breakwater is proposed (Options 2 and 4), there is the issue of material handling. First, the excavated material will require a storage area. The material could be stored off-site which would require trucking, or it could be stored on barges which would be moored around the site. Putting the material on barges would require numerous barges and a large mooring area. The second problem with excavation would be the access to the facility. During excavation procedures the breakwater would be closed to major traffic. This would cause a devastating blow to shipping in this vicinity if the new marine terminal was not in operation, thereby making this option less desirable. If excavation methods are used in the rehabilitation of the breakwater it would be critical to plan construction after the opening of the new facility.

6.0 RECOMMENDATIONS

In assessing the feasibility of the "king-pile" system (Option 3), it was found that its costs were higher than the other Options because of the greater amount of steel required for the piling, and therefore was not competitive with the other Alternatives.

The selection of the Alternative is dependant on the timing of the repair and the level of disruption that can be tolerated. In comparing the cost estimates for the different options, it is evident that Option 2 and 4 are the most economical, but require excavation of the breakwater. What the cost estimates do not take into account is the possible economic impact the construction will have on the local area. If the new marine terminal has opened and the traffic at the breakwater has declined, Option 2 may be the methodology to follow. If, however, the amount of time that the breakwater would be closed is too great, but partial disruption could be tolerated, then Option 4 could possibly be performed in phases.

If no disruption can be tolerated, then Option 1A would be the next recommended alternative. By using the proposed horizontal drilling methods, the access to the breakwater could be maintained at current levels. Although no major construction would actually be occurring on the deck of the breakwater, some areas would still be needed as a staging area for the construction. Of these alternatives Option 1B (bundled strands) is the most cost effective, however, Option 1A (threadbar) is recommended,. since it is less sensitive to corrosion.

EASTPORT HARBOR - FEDERAL BREAKWATER May 11, 1994

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OPTION 1A - Horizontal Drilling for tie backs using Threadbar

COST ESTIMATE

DESCRIPTION	UNIT	UNIT COST	QUANTITY	COST
SHEET PILING				
PZ27 - A575 Gr 50 (driven)	sq ft	$20.25	24,600	**$498,150**
PZ27 - A575 Gr 50 (wrapped)	sq ft	$24.30	12,960	**$314,928**
WALE				
HP14x89 - A572 Gr 50	lbs	$1.75	274,120	**$479,710**
TIE RODS				
2-1/2" Threadbar - Gr 150	assembly	$1,800.00	49	**$88,200**
FENDER SYSTEM				
10"x10" Timber @ 9' O.C.	each	$650.00	48	**$31,200**
Blocking @ 4 points	each	$600.00	48	**$28,800**
CONSTRUCTION				
Installation of Weep Holes	each	$300.00	77	**$23,100**
Treme Concrete fill at base of Sheeting	cu yds	$150.00	62	**$9,300**
Fill between Sheeting w/ stone *	cu yds	$30.00	1,435	**$43,050**
Drilling and Installation for Tie Rods				
@ Elevation +16 @ 23' O.C.	each	$6,700.00	30	**$201,000**
@ Elevation +4 @ 13' O.C.	each	$8,000.00	19	**$152,000**
		SUBTOTAL		**$1,869,438**
		10% CONTINGENCY		**$186,562**
		ENGINEERING FEES		**$150,000**
		TOTAL		**$2,206,000**

* To fill void between sheets with concrete increase price to $100/cu yds

EASTPORT HARBOR - FEDERAL BREAKWATER May 11, 1994

Job Number: 94086 Eastport Port Authority

OPTION 1B - Horizontal Drilling for tie backs using Bundled Strands

COST ESTIMATE

DESCRIPTION	UNIT	UNIT COST	QUANTITY	COST
SHEET PILING				
PZ27 - A575 Gr 50 (driven)	sq ft	$20.25	24,600	**$498,150**
PZ27 - A575 Gr 50 (wrapped)	sq ft	$24.30	12,960	**$314,928**
WALE				
W24x94 - A572 Gr 50	lbs	$1.75	289,520	**$506,660**
TIE RODS				
19 0.6" Bundled Strands - A416	assembly	$1,600.00	36	**$57,600**
FENDER SYSTEM				
10"x10" Timber @ 9' O.C.	each	$650.00	48	**$31,200**
Blocking @ 4 points	each	$600.00	48	**$28,800**
CONSTRUCTION				
Installation of Weep Holes	each	$300.00	77	**$23,100**
Treme Concrete fill at base of Sheeting	cu yds	$150.00	62	**$9,300**
Fill between Sheeting w/ stone *	cu yds	$30.00	1,435	**$43,050**
Drilling and Installation for Tie Rods				
@ Elevation +16 @ 32' O.C.	each	$7,500.00	22	**$165,000**
@ Elevation +4 @ 18' O.C.	each	$8,500.00	14	**$119,000**
		SUBTOTAL		**$1,796,788**
		10% CONTINGENCY		**$179,212**
		ENGINEERING FEES		**$140,000**
		TOTAL		**$2,116,000**

* To fill void between sheets with concrete increase price to $100/cu yds

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Job Number: 94086 Eastport Port Authority

OPTION 2 - Excavation for tie backs using Threadbar

COST ESTIMATE

DESCRIPTION	UNIT	UNIT COST	QUANTITY	COST
SHEET PILING				
PZ27 - A575 Gr 50 (driven)	sq ft	$20.25	24,600	**$498,150**
PZ27 - A575 Gr 50 (wrapped)	sq ft	$24.30	12,960	**$314,928**
WALE				
C12x25 - A572 Gr 50	lbs	$1.75	38,500	**$67,375**
C15x50 - A573 Gr 50	lbs	$1.75	77,000	**$134,750**
TIE RODS				
1-1/4" Threadbar - Gr 150 @ 12' O.C.	assembly	$375.00	32	**$12,000**
1-3/8" Threadbar - Gr 150 @ 6' O.C.	assembly	$450.00	62	**$27,900**
FENDER SYSTEM				
10"x10" Timber @ 9' O.C.	each	$650.00	48	**$31,200**
Blocking @ 4 points	each	$600.00	48	**$28,800**
CONSTRUCTION				
Installation of Weep Holes	each	$300.00	77	**$23,100**
Treme Concrete fill at base of Sheeting	cu yds	$150.00	62	**$9,300**
Fill between Sheeting w/ stone *	cu yds	$30.00	1,435	**$43,050**
Excavation and Backfill of Breakwater	cu yds	$12.00	15,700	**$188,400**
Asphalt Paving of Deck	ton	$70.00	420	**$29,400**
Installation of Tie Rods	assembly	$350.00	94	**$32,900**
		SUBTOTAL		**$1,441,253**
		10% CONTINGENCY		**$143,747**
		ENGINEERING FEES		**$125,000**
		TOTAL		**$1,710,000**

* To fill void between sheets with concrete increase price to $100/cu yds

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Job Number: 94086 Eastport Port Authority

OPTION 3 - "King Pile" Wall with Drilling for tie backs using Threadbar
COST ESTIMATE

DESCRIPTION	UNIT	UNIT COST	QUANTITY	COST
SHEET PILING				
HZ 575 A Comb10/13 - A575 Gr 50 (drive	lbs	$1.00	973,300	**$973,300**
PZ27 - A575 Gr 50 (wrapped)	sq ft	$24.30	12,960	**$314,928**
WALE				
C12x20.7 - A572 Gr 50	lbs	$1.75	16,974	**$29,705**
C15x40 - A572 Gr 50	lbs	$1.75	28,800	**$50,400**
C15x50 - A572 Gr 50	lbs	$1.75	36,000	**$63,000**
TIE RODS				
2-1/2" Threadbar - Gr 150 @ 7.5' O.C.	assembly	$1,800.00	48	**$86,400**
FENDER SYSTEM				
10"x10" Timber @ 9' O.C.	each	$650.00	48	**$31,200**
Blocking @ 4 points	each	$600.00	48	**$28,800**
CONSTRUCTION				
Installation of Weep Holes	each	$300.00	77	**$23,100**
Treme Concrete fill at base of Sheeting	cu yds	$150.00	62	**$9,300**
Fill between Sheeting w/ stone *	cu yds	$30.00	1,890	**$56,700**
Drilling and Installation for Tie Rods	each	$5,700.00	48	**$273,600**
		SUBTOTAL		**$1,940,433**
		10% CONTINGENCY		**$193,567**
		ENGINERING FEES		**$150,000**
		TOTAL		**$2,284,000**

* To fill void between sheets with concrete increase price to $100/cu yds

EASTPORT HARBOR - FEDERAL BREAKWATER May 11, 1994

Job Number: 94086 Eastport Port Authority

OPTION 4 - Excavate to top tie backs and Horizontal Drill lower tie backs using Threadbar
COST ESTIMATE

DESCRIPTION	UNIT	UNIT COST	QUANTITY	COST
SHEET PILING				
PZ27 - A575 Gr 50 (driven)	sq ft	$20.25	24,600	**$498,150**
PZ27 - A575 Gr 50 (wrapped)	sq ft	$24.30	12,960	**$314,928**
WALE				
HP14x89 - A572 Gr 50	lbs	$1.75	137,060	**$239,855**
C12x25 - A572 Gr 50	lbs	$1.75	38,500	**$67,375**
TIE RODS				
2-1/2" Threadbar - Gr 150 @ 13' O.C.	assembly	$1,800.00	19	**$34,200**
1-1/4" Threadbar - Gr 150 @ 6' O.C.	assembly	$375.00	32	**$12,000**
FENDER SYSTEM				
10"x10" Timber @ 9' O.C.	each	$650.00	48	**$31,200**
Blocking @ 4 points	each	$600.00	48	**$28,800**
CONSTRUCTION				
Installation of Weep Holes	each	$300.00	77	**$23,100**
Treme Concrete fill at base of Sheeting	cu yds	$150.00	62	**$9,300**
Fill between Sheeting w/ stone *	cu yds	$30.00	1,435	**$43,050**
Excavation and Backfill of Breakwater	cu yds	$12.00	7,700	**$92,400**
Asphalt Paving of Deck	ton	$70.00	420	**$29,400**
Drilling and Installation for Tie Rods	each	$8,000.00	19	**$152,000**
Installation of Tie Rods	assembly	$350.00	32	**$11,200**
		SUBTOTAL		**$1,586,958**
		10% CONTINGENCY		**$158,042**
		ENGINEERING FEES		**$125,000**
		TOTAL		**$1,870,000**

* To fill void between sheets with concrete increase price to $100/cu yds

NOTES:

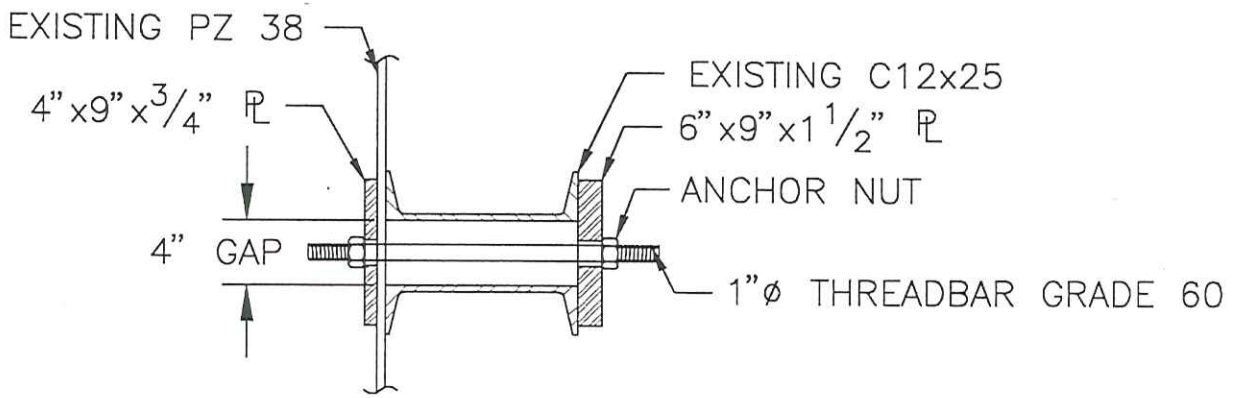
DO NOT CUT EXISTING WALE/SHEET PILE CONNECTION BOLTS. REMOVE ONLY THOSE BOLTS THAT HAVE FAILED.

INSTALL 1 NEW BOLT @ EACH INDENT OF SHEETING. PLACE BOLT ON EITHER SIDE OF INTERLOCK.

TIE RODS SHALL BE CONTINUOUSLY THREADED AND SHALL CONFORM TO ASTM A615 (GRADE 60) AND SHALL BE FUSION BONDED EPOXY COATED, ALONG WITH ALL HARDWARE.

WHERE WALE HAS SETTLED, SECURE AREAS BEYOND SETTLEMENT AND THEN RAISE WALE TO ORIGINAL LOCATION.

WHERE CONTINUOUS GAP EXISTS BETWEEN WALE AND SHEETING EXCAVATE BELOW WALE AS FAR AS PRACTICLE (MAX 6'). INSTALL NEW WALE/SHEETING CONNECTION AND TIGHTEN AS MUCH AS POSSIBLE WITHOUT DAMAGING WALE OR SHEETING.



WALE CONNECTION @ EL +16.0

SCALE: 1" = 1'– 0"

STEEL BULKHEAD REPAIR

EASTPORT PORT AUTHORITY

EASTPORT, MAINE

APRIL 1994

REVISIONS	

BCE Bourne Consulting Engineering

430 Franklin Village Drive, Suite 145, Franklin, MA 02038

DRAWN: BAP
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APPROVED:
DATE: MAY, 1994

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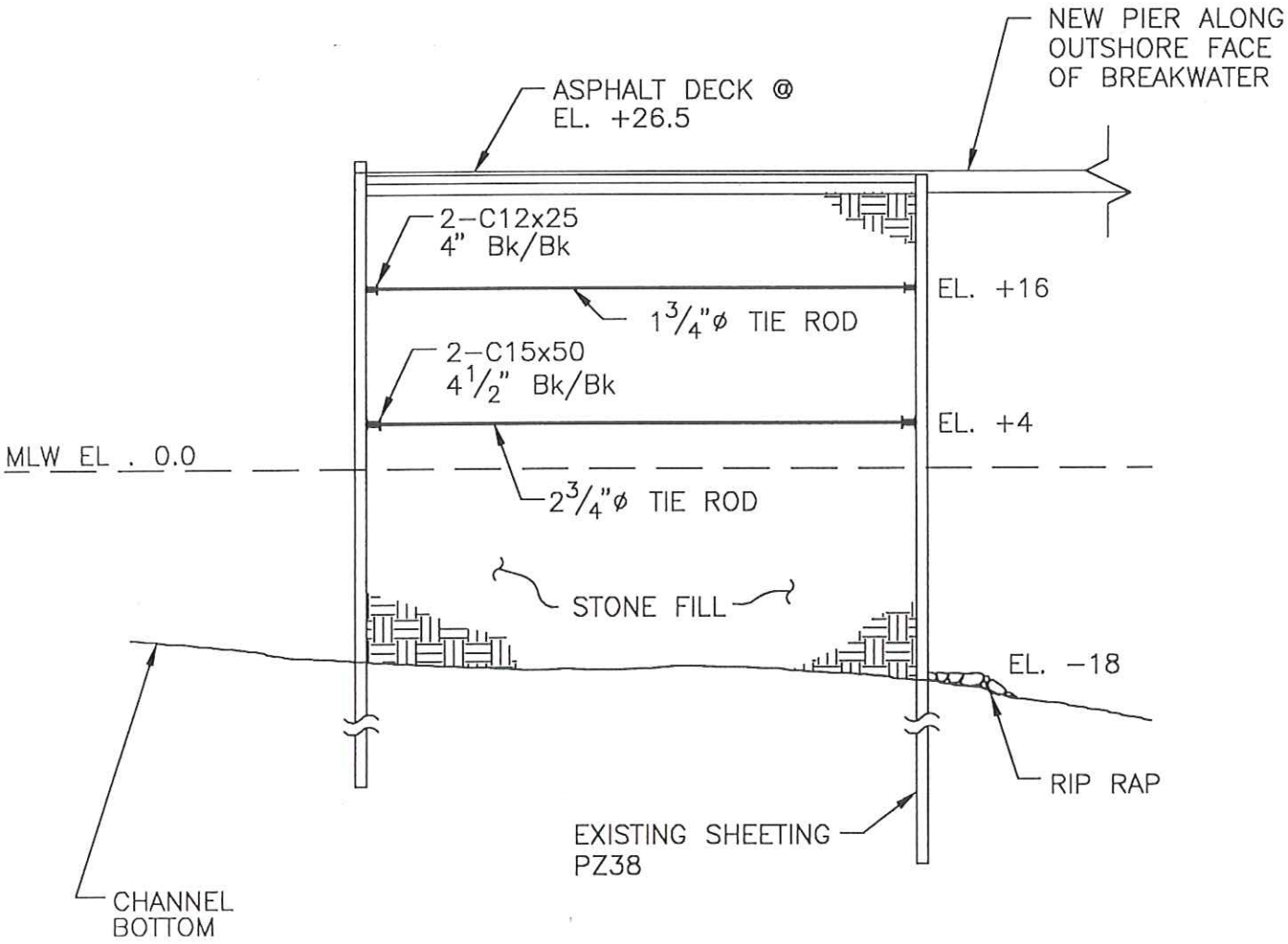
SHEET 1 OF 6



EXISTING CONDITIONS
TYPICAL SECTION
FEDERAL BREAKWATER

EASTPORT PORT AUTHORITY
EASTPORT HARBOR
EASTPORT, MAINE

0 16' 32'

SCALE: 1/16" = 1'–0"

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BCE Bourne Consulting Engineering
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DATE: MAY, 1995

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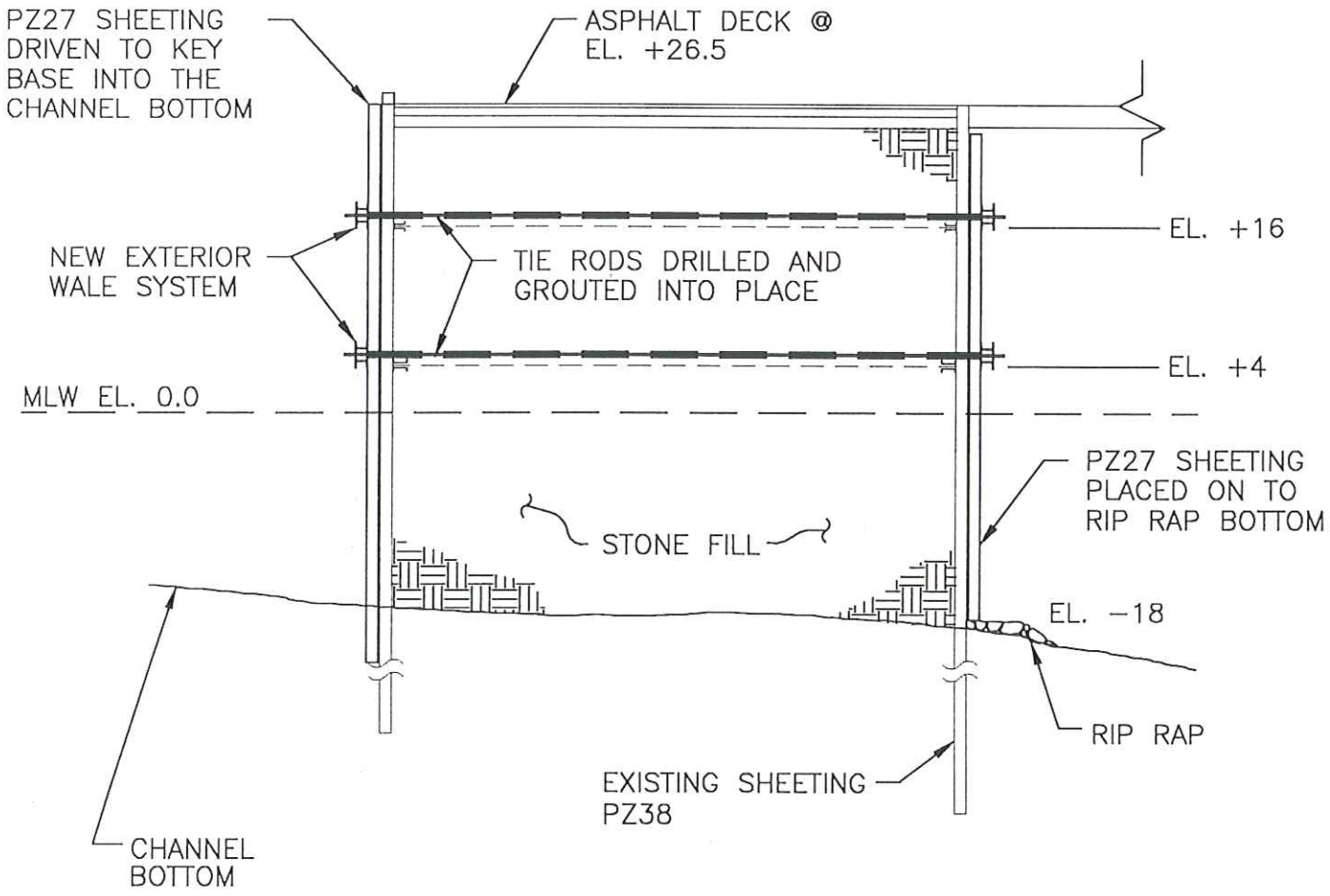
SHEET 2 OF 6



OPTION 1A &1B
TYPICAL SECTION
FEDERAL BREAKWATER

EASTPORT PORT AUTHORITY
EASTPORT HARBOR
EASTPORT, MAINE

0 16' 32'

SCALE: 1/16" = 1'-0"

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DATE: MAY, 1995

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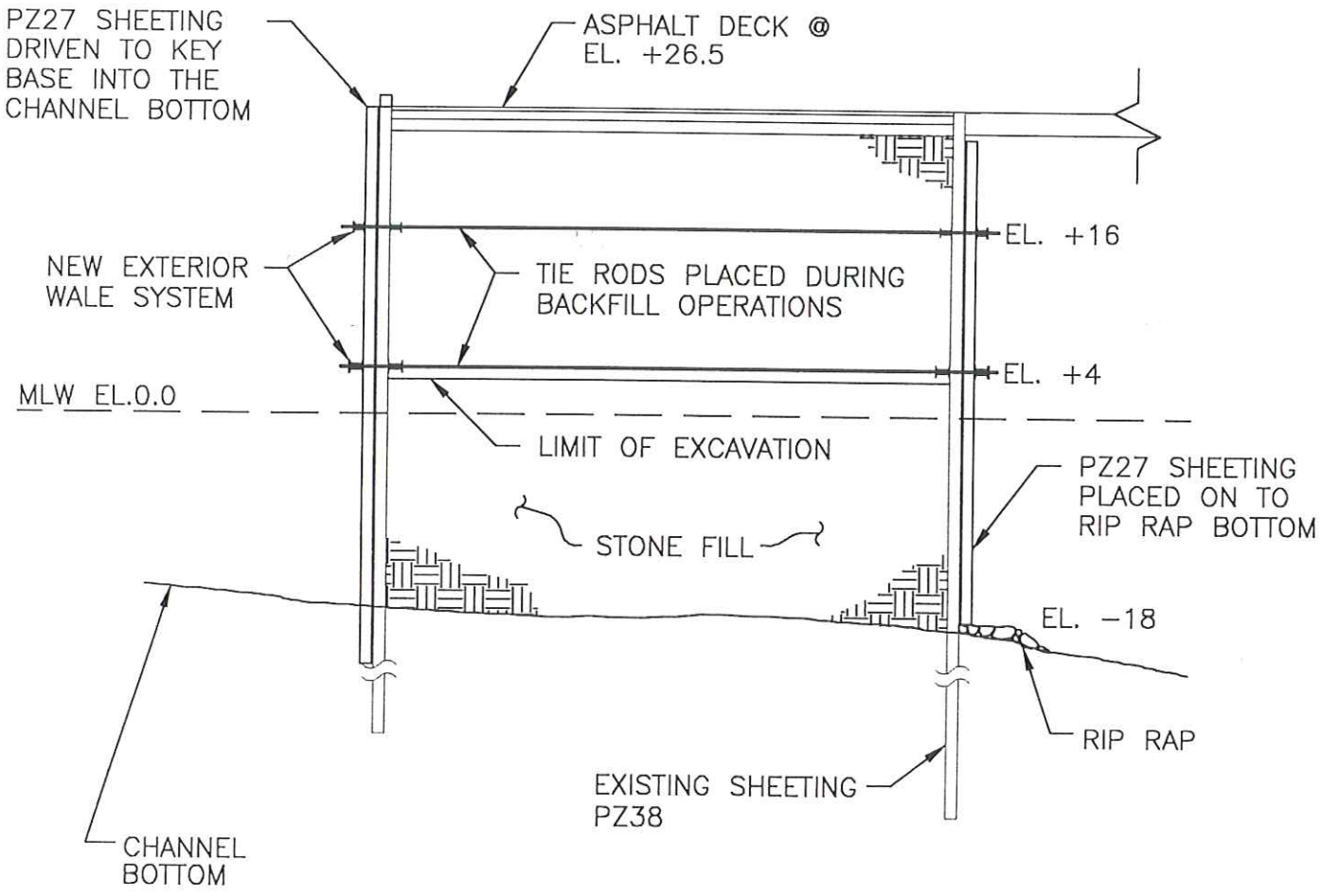
SHEET 3 OF 6



OPTION 2
TYPICAL SECTION
FEDERAL BREAKWATER

EASTPORT PORT AUTHORITY
EASTPORT HARBOR
EASTPORT, MAINE

0 16' 32'

SCALE: 1/16" = 1'−0"

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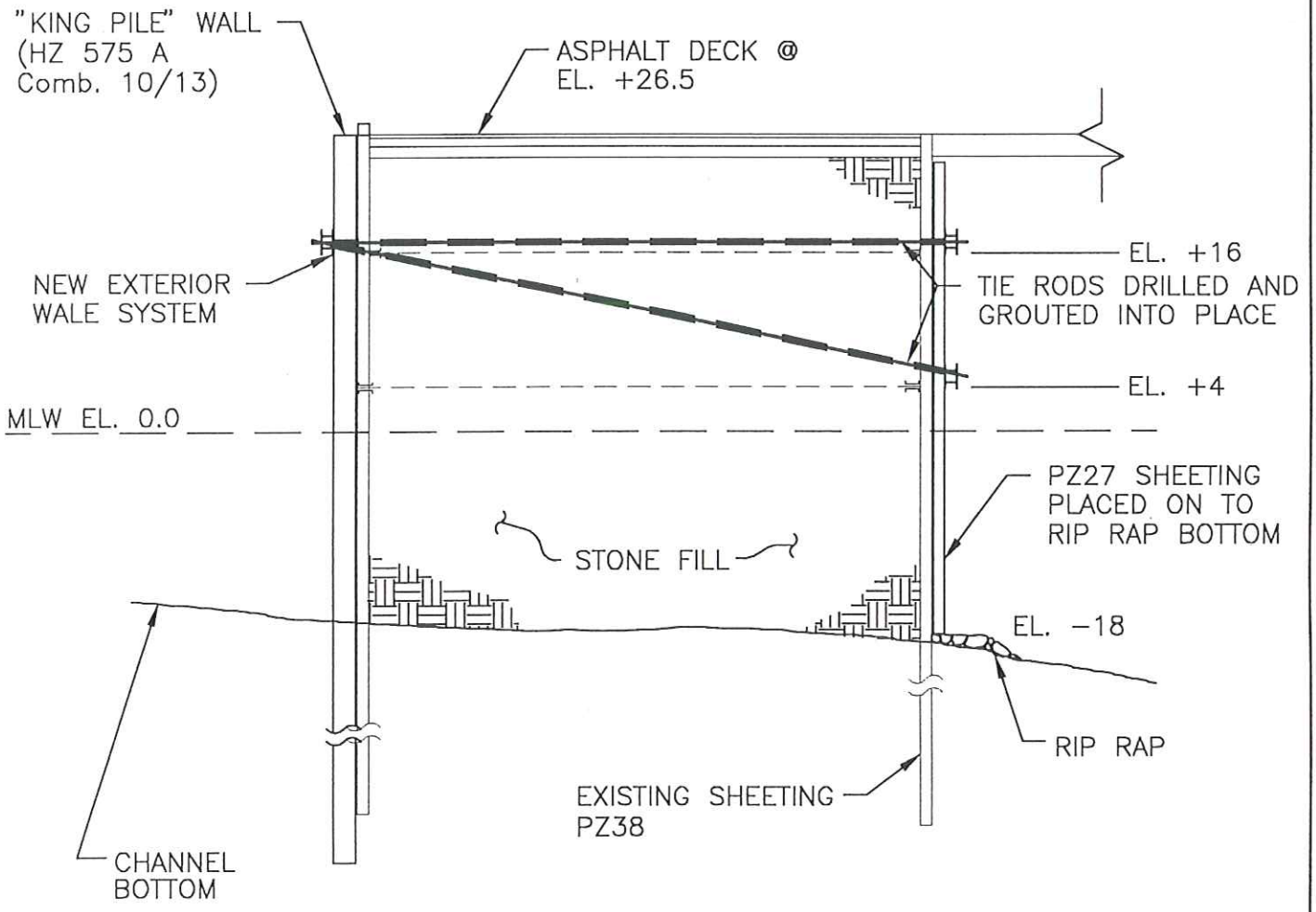
SHEET 4 OF 6



OPTION 3
TYPICAL SECTION
FEDERAL BREAKWATER

EASTPORT PORT AUTHORITY
EASTPORT HARBOR
EASTPORT, MAINE

0 16' 32'

SCALE: 1/16" = 1'-0"

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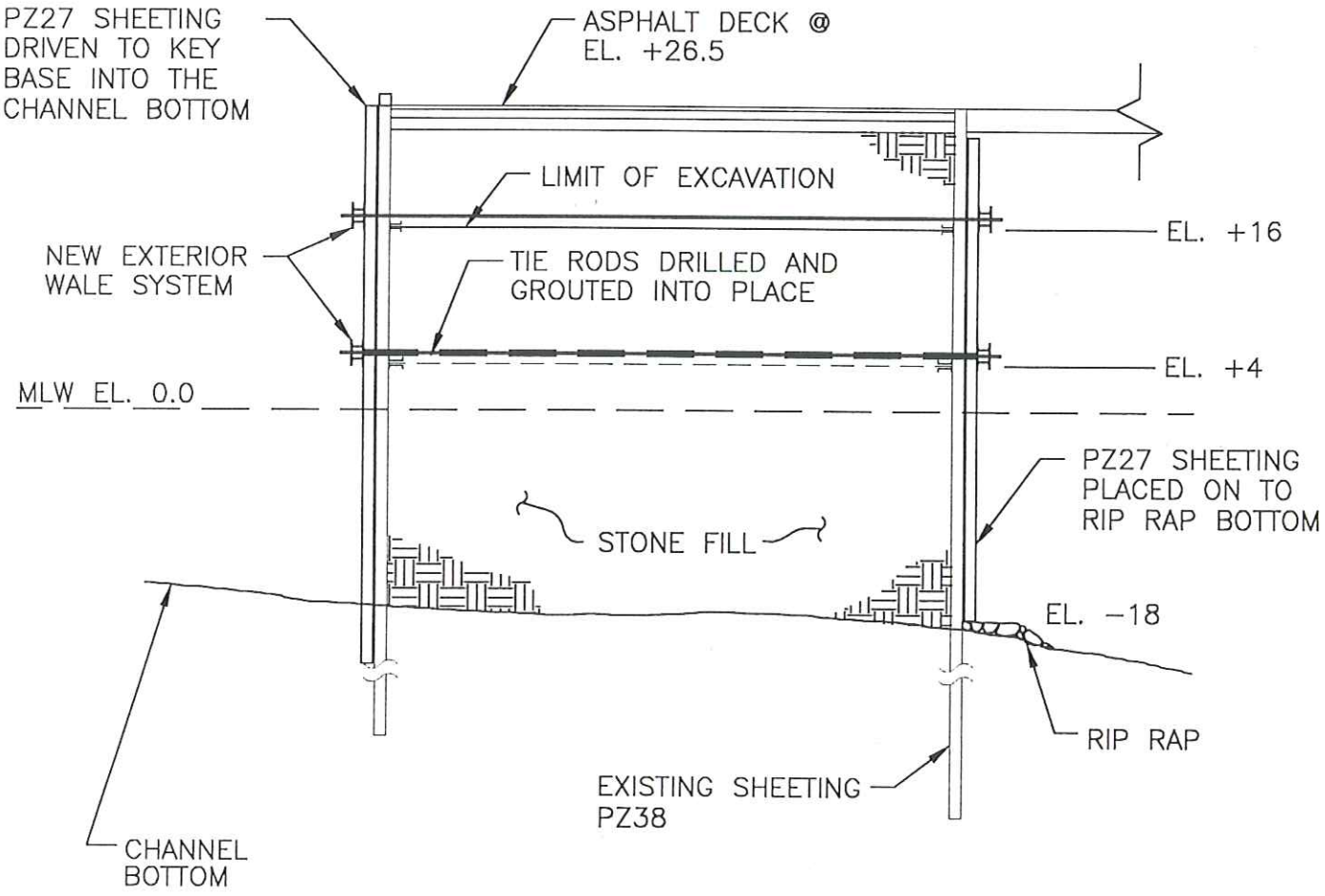
SHEET 5 OF 6



OPTION 4
TYPICAL SECTION
FEDERAL BREAKWATER

EASTPORT PORT AUTHORITY
EASTPORT HARBOR
EASTPORT, MAINE

0 16' 32'

SCALE: 1/16" = 1'-0"

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